

flow metering using critical flow orifice devices.)

(1) Obtain a small cylinder that has been charged with 99.5 percent or greater propane or carbon monoxide gas (Caution—carbon monoxide is poisonous).

(2) Determine a reference cylinder weight to the nearest 0.01 grams.

(3) Operate the CVS in the normal manner and release a quantity of pure propane into the system during the sampling period (approximately 5 minutes).

(4) The calculations are performed in the normal way except in the case of propane. The density of propane (0.6109 kg/m³/carbon atom)) is used in place of the density of exhaust hydrocarbons.

(5) The gravimetric mass is subtracted from the CVS measured mass and then divided by the gravimetric mass to determine the percent accuracy of the system.

(6) Good engineering practice requires that the cause for any discrepancy greater than ± 2 percent must be found and corrected.

§ 89.423-96 CVS calibration frequency.

The CVS positive displacement pump or critical flow venturi shall be calibrated following initial installation, major maintenance or as necessary when indicated by the CVS system verification (described in § 89.352-96(e)).

§ 89.424-96 Dilute emission sampling calculations.

(a) The final reported emission test results are computed by use of the following formula:

$$A_{WM} = \frac{\sum_{i=1}^{i=n} (g_i \times WF_i)}{\sum_{i=1}^{i=n-1} (kW-hr_i \times WF_i)}$$

Where:

A_{wm} = Weighted mass emission level (HC, CO, CO₂, or NO_x) in grams per kilowatt-hour.

g_i = Mass emission level in grams, measured during the mode.

WF_i = Effective weighing factor.

$kW-hr_i$ = Total kilowatt-hours (kilowatts integrated over time) for the mode.

(b) The mass of each pollutant for each mode for bag measurements and diesel heat exchanger system measurements is determined from the following equations:

(1) Hydrocarbon mass:

$$HC_{mass} = V_{mix} \times \text{Density}_{HC} \times (HC_{conc}/10^6)$$

(2) Oxides of nitrogen mass:

$$NO_{xmass} = V_{mix} \times \text{Density}_{NO_2} \times KH \times (NO_{xconc}/10^6)$$

(3) Carbon monoxide mass:

$$CO_{mass} = V_{mix} \times \text{Density}_{CO} \times (CO_{conc}/10^6)$$

(4) Carbon dioxide mass:

$$CO_{2mass} = V_{mix} \times \text{Density}_{CO_2} \times (CO_{2conc}/10^6)$$

(c) The mass of each pollutant for the mode for flow compensated sample systems is determined from the following equations:

$$HC_{mass} = V_{mix} \times \text{Density}_{HC} \frac{HC_e - HC_d \left(1 - \frac{1}{DF}\right)}{10^6}$$

$$\text{NOX}_{\text{mass}} = K_H \frac{\text{NOX}_e - \text{NOX}_d \left(1 - \frac{1}{\text{DF}}\right)}{10^6} V_{\text{mix}} \times \text{Density}_{\text{NO}_2}$$

$$\text{CO}_{\text{mass}} = V_{\text{mix}} \times \text{Density}_{\text{CO}} \frac{\text{CO}_c - \text{CO}_d \left(1 - \frac{1}{\text{DF}}\right)}{10^6}$$

$$\text{CO}_{2\text{mass}} = V_{\text{mix}} \times \text{Density}_{\text{CO}_2} \frac{\text{CO}_{2e} - \text{CO}_{2d} \left(1 - \frac{1}{\text{DF}}\right)}{10^6}$$

(d) Meaning of symbols:

(1) For hydrocarbon equations:

HC_{mass} = Hydrocarbon emissions, in grams per test mode.

$\text{Density}_{\text{HC}}$ = Density of hydrocarbons is (.5800 kg/m³) for #1 diesel, and (0.5746 kg/m³) for #2 diesel, assuming an average carbon to hydrogen

ratio of 1:1.93 for #1 diesel, and 1:1.80 for #2 diesel at 20 °C and 101.3 kPa pressure.

HC_{conc} = Hydrocarbon concentration of the dilute exhaust sample corrected for background, in ppm carbon equivalent (that is, equivalent propane times 3).

$$HC_{\text{conc}} = HC_e - HC_d \left(1 - \frac{1}{\text{DF}}\right)$$

Where:

HC_e = Hydrocarbon concentration of the dilute exhaust bag sample or, for diesel heat exchanger systems, average hydrocarbon concentration of the dilute exhaust sample as calculated from the integrated HC traces, in ppm carbon equivalent. For flow compensated sample systems (HC_e)_i is the instantaneous concentration.

HC_d = Hydrocarbon concentration of the dilution air as measured, in ppm carbon equivalent.

(2) For oxides of nitrogen equations:

NOX_{mass} = Oxides of nitrogen emissions, in grams per test mode.

$\text{Density}_{\text{NO}_2}$ = Density of oxides of nitrogen is 1.913 kg/m³, assuming they are in the form of nitrogen dioxide, at 20 °C and 101.3 kPa pressure.

NOX_{conc} = Oxides of nitrogen concentration of the dilute exhaust sample corrected for background, in ppm:

$$\text{NOX}_{\text{conc}} = \text{NOX}_e - \text{NOX}_d \left(1 - \frac{1}{\text{DF}}\right)$$

Where:

NOX_e = Oxides of nitrogen concentration of the dilute exhaust bag sample as measured, in ppm. For flow compensated sample systems (NOX_e)_i is the instantaneous concentration.

NOX_d = Oxides of nitrogen concentration of the dilute air as measured, in ppm.

(3) For carbon monoxide equations:

CO_{mass} = Carbon monoxide emissions, grams per test mode. $\text{Density}_{\text{CO}}$ = Density of carbon monoxide (1.164 kg/m³ at 20 °C and 101.3 kPa pressure).

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CO_{conc} =Carbon monoxide concentration of the dilute exhaust sample corrected for background, water vapor, and CO_2 extraction, ppm.

$$CO_{conc} = CO_e - CO_d \left(1 - \frac{1}{DF} \right)$$

Where:

CO_e =Carbon monoxide concentration of the dilute exhaust bag sample volume corrected for water vapor and carbon dioxide extraction, ppm. For flow compensated sample systems, $(CO_e)_i$ is the instantaneous concentration.

The following calculation assumes the carbon to hydrogen ratio of the

fuel is 1:1.85. As an option the measured actual carbon to hydrogen ratio may be used:

$$CO_e = [1 - 0.01925CO_{2e} - 0.000323R] CO_{em}$$

Where:

CO_{em} =Carbon monoxide concentration of the dilute exhaust sample as measured, ppm.

CO_{2e} =Carbon dioxide concentration of the dilute exhaust bag sample, in percent, if measured. For flow compensated sample systems, $(CO_{2e})_i$ is the instantaneous concentration. For cases where exhaust sampling of CO_2 is not performed, the following approximation is permitted:

$$CO_{2e} = \frac{44.010}{12.011 + 1.008\alpha} \frac{M^1}{Density_{CO_2}} \frac{100}{V_{mix}}$$

^a=Average carbon to hydrogen ratio.

M^1 =Fuel mass consumed during the test cycle.

R =Relative humidity of the dilution air, percent.

CO_d =Carbon monoxide concentration of the dilution air corrected for water vapor extraction, ppm.

$$CO_d = (1 - 0.000323R) CO_{dm}$$

Where:

CO_{dm} =Carbon monoxide concentration of the dilution air sample as measured, ppm.

NOTE: If a CO instrument which meets the criteria specified in §86.1311-90 of this chapter is used and the conditioning column has been deleted, CO_{em} must be substituted directly for CO_e and CO_{dm} must be substituted directly for CO_d .

(4) For carbon dioxide equation:

CO_{2mass} =Carbon dioxide emissions, in grams per test mode.

$Density_{CO_2}$ =Density of carbon dioxide is 1.830 kg/m³, at 20 °C and 760 mm Hg pressure.

CO_{2conc} =Carbon dioxide concentration of the dilute exhaust sample corrected for background, in percent.

$$CO_{2mass} = CO_{2e} - CO_{2d} \left(1 - \frac{1}{DF} \right)$$

Where:

CO_{2d} =Carbon dioxide concentration of the dilution air as measured, in percent.

$$(5) DF = \frac{13.4}{CO_{2e} + (HC_e + CO_e \times 10^{-4})}, \text{ or } DF = \frac{13.4}{CO_{2e}}$$

(6) KH =Humidity correction factor. For compression-ignition engines:

$$KH = 1/[1 - 0.0182 (H - 10.71)].$$

Where:

H =Absolute humidity of the engine intake air in grams of water per kilogram of dry air and

$$H = (6.211)R_i \times P_d / (P_b - (P_d \times R_i / 100))$$

Where:

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R_i =Relative humidity of the engine intake air, in percent.

P_d =Saturated vapor pressure (kPa) at the engine intake air dry bulb temperature.

P_B =Barometric pressure (kPa).

(e) The final reported brake-specific fuel consumption (*BSFC*) shall be computed by use of the following formula:

$$BSFC = \frac{M}{kW - hr}$$

Where:

BSFC=brake-specific fuel consumption in grams of fuel per kilowatt-hr (kW-hr)

M =mass of fuel in grams, used by the engine during a mode

kW-hr=total kilowatts integrated with respect to time for a mode

(f) The mass of fuel for the mode is determined from mass fuel flow measurements made during the mode, or from the following equation:

$$M = \left(\frac{G_s}{R_2} \right) \left(\frac{1}{273.15} \right)$$

Where:

M =Mass of fuel, in grams, used by the engine during the mode.

G_s =Grams of carbon measured during the mode:

$$G_s = \left[\frac{12.011}{12.011 + \alpha (1.008)} \right] HC_{mass} + 0.429 CO_{mass} + 0.273 CO_{2mass}$$

R_2 =Grams C in fuel per gram of fuel

Where:

HC_{mass} =hydrocarbon emissions, in grams for the mode

CO_{2mass} =carbon monoxide emissions, in grams for the mode

CO_{2mass} =carbon dioxide emissions, in grams for the mode

α =The atomic hydrogen to carbon ratio of the fuel.

§ 89.425-96 Particulate adjustment factor.

The following equation may be used to adjust the particulate measurement when the test fuel specified in Table 4 of Subpart D of this Part is used:

$$PM_{adj} = PM - [BSFC * (FSF - USLF_{CA})] * 0.0917$$

Where:

PM_{adj} =adjusted measured PM level [g/Kw-hr]

PM =measured weighted PM level [g/Kw-hr]

$BSFC$ =measured brake specific fuel consumption [G/Kw-hr]

FSF =fuel sulfur weight fraction

$USLF_{CA}$ =upper sulfur level weight fraction of California specification.

This adjustment only applies to engines with no exhaust gas after treatment. No adjustment is provided for engines with exhaust gas after treatment.